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Colorado State Univ, Fort Collins Dept of Industrial Sciences

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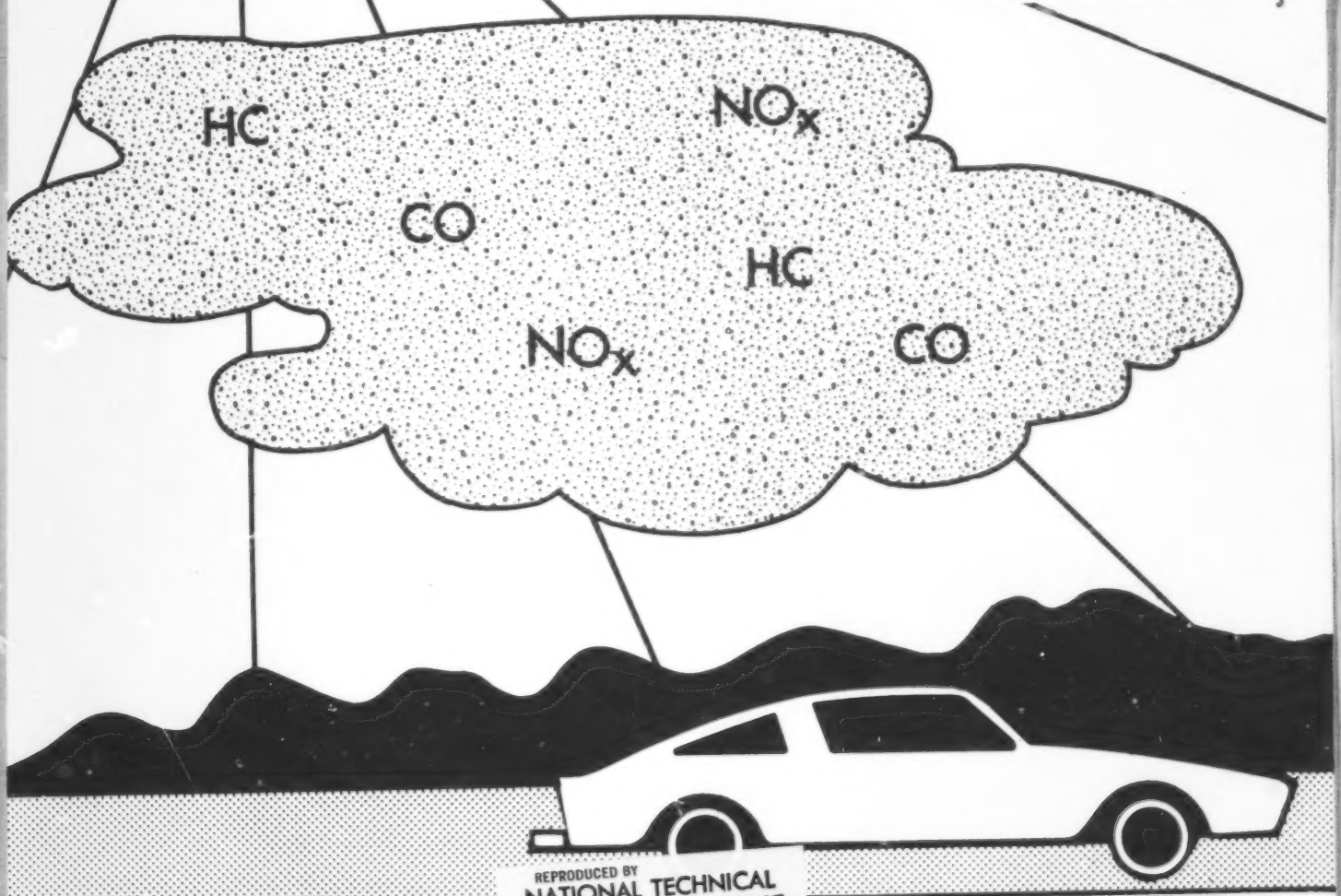
MOTOR VEHICLE EMISSIONS CONTROL BOOK SEVEN CATALYTIC CONVERTER SYSTEMS



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16. ABSTRACT

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. It is intended to assist the practicing mechanic or the home mechanic to better understand the Catalytic Converter Systems which are an integral part of automobiles today. The mechanic's increased knowledge should help him keep "emissions controlled" vehicles operating as designed. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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System Inspection	Monolith Converter		
Hydrocarbons	Pellet Converter		
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MOTOR VEHICLE EMISSIONS CONTROL
BOOK SEVEN
CATALYTIC CONVERTER SYSTEMS

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MOTOR VEHICLE EMISSIONS CONTROL

-- SERIES OF SEVEN BOOKS --

MOTOR VEHICLE EMISSIONS STAFF, COLORADO STATE UNIVERSITY

BOOK ONE - POSITIVE CRANKCASE VENTILATION SYSTEMS

BOOK TWO - THERMOSTATIC AIR CLEANER SYSTEMS

BOOK THREE - AIR INJECTION REACTION SYSTEMS

BOOK FOUR - FUEL EVAPORATION CONTROL SYSTEMS

BOOK FIVE - EXHAUST GAS RECIRCULATION SYSTEMS

BOOK SIX - SPARK CONTROL SYSTEMS

BOOK SEVEN - CATALYTIC CONVERTER SYSTEMS

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A special thanks must be extended to the automotive vehicle equipment and parts manufacturers for their cooperation and assistance in the development of this training material.

INSTRUCTIONS FOR THE USE OF THIS BOOK

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. Each book is designed to be used as self-instructional material. Therefore, it is important that you follow the step-by-step procedure format so that you may realize the full value of the emissions system which is being presented. The topics are taught in incremental steps and each topic treatment prepares the student for the next topic. Each book is divided into sections which include the introduction, purpose, function, inspection and testing of the emissions system presented.

As you proceed through this series, please begin with book one and read the following books in sequence. This is important because there are several instances where material covered in a given book relies on previously covered material in another book.

To receive the full benefits of the book, please answer the self-evaluation statements related to the material. These statements are separated from the text by solid lines crossing the page. The answers to the statement can be found at the end of the book as identified by the table of contents. You should check for the correct answer after you respond to each statement. If you find that you have made a mistake, go back through the material which relates to the statement or statements.

Fill-in-the-blank statements are utilized for self-evaluation purposes throughout the material. An example statement would appear like this:

The American flag is red, white, and _____.

You would write "blue" in the blank and immediately check your answer at the end of the book.

The material, statements and illustrations should be easy to follow and understand. In several illustrations a small ghost named "VEC" (Vehicle Emissions Control) has been used to make the picture easier to understand.

Upon completion of this series, you should be able to better understand the emissions control systems and devices which are an integral part of automobiles today. Your increased knowledge should help you keep these "emissions controlled" vehicles operating as they were designed to operate. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

CONTENTS

Introduction to Emissions Control 7-1
Hydrocarbons 7-1
Carbon Monoxide 7-1
Oxides of Nitrogen 7-2
Formation of Hydrocarbons 7-2
Formation of Carbon Monoxide 7-3
Formation of Oxides of Nitrogen 7-3
Ignition Timing 7-3
Carburetion 7-5
System Introduction 7-7
System/Component Purpose 7-9
System/Component Function 7-11
Monolith Type Converter 7-13
Pellet Type Converter 7-15
Catalysts 7-17
Catalyst Protection Systems 7-21
System Inspection 7-33
System Testing 7-35
System Summary 7-37
Answers 7-39

INTRODUCTION TO EMISSIONS CONTROL

As we all know emissions systems and devices have been installed on the automobile engine because of the air pollution problem. In order for you to understand these emissions systems and devices you should have a background of the problem. All of the emissions control systems were installed on the engine to reduce just three specific exhaust products. These are known as products of combustion. The three products which the emissions systems are designed to reduce are hydrocarbons, carbon monoxide and oxides of nitrogen.

HYDROCARBONS

Gasoline, like all petroleum products, is made up of hundreds of hydrocarbon compounds. The name "hydrocarbon" has been given to these compounds because they are made up of hydrogen and carbon atoms. This is also the reason hydrocarbons have the abbreviation (HC).

48

Hydrocarbons are gasoline vapors or raw gasoline itself. One reason hydrocarbon emissions must be controlled is because it is one of the major components of photochemical smog. Photochemical or "Los Angeles" smog forms when hydrocarbons and oxides of nitrogen combine in the presence of sunlight. In order to avoid this smog condition the hydrocarbon emissions from automobiles must be controlled. Hydrocarbons also act as an irritant to our eyes and some are suspected of causing cancer and other health problems.

CARBON MONOXIDE

Another product of combustion that must be controlled is carbon monoxide. Carbon monoxide has the abbreviation (CO). CO is also hazardous to our health when it is mixed with the air we breathe. It can cause headaches, reduce mental alertness and even cause death if enough of it is in the air. Carbon monoxide is also a problem in that it speeds the formation of photochemical smog. For these reasons CO emissions must be controlled.

OXIDES OF NITROGEN

Oxides of nitrogen are the last harmful products of combustion we will discuss. Nitrogen oxides have been given the abbreviation (NO_x). As you already know, oxides of nitrogen and hydrocarbons combine to form photochemical smog. The sunlight which triggers the formation of photochemical smog has another effect on oxides of nitrogen. Some of the oxides of nitrogen are broken down and a gas called ozone is formed. Ozone is a lung and eye irritant and it also deteriorates rubber and affects the growth of vegetation. Since the nitrogen oxides have these effects they must also be controlled.

Now that you are familiar with the emissions which must be controlled let's find out where they originate.

FORMATION OF HYDROCARBONS

Hydrocarbons, you will recall, are fuel vapors or raw fuel. For this reason hydrocarbon emissions will result from any uncontained supply of gasoline. Hydrocarbon emissions also come from the tailpipe. If the automobile engine could achieve "complete combustion," all of the unburned fuel or hydrocarbons would be used up. However, it is impossible for today's automobile engines to achieve "complete combustion." Any time the fuel mixture in the combustion chamber is not completely burned, some hydrocarbons will be emitted from the tailpipe. The two main reasons why hydrocarbons are not completely burned are because of engine misfire and "quench areas." When an engine misfire occurs, none of the raw fuel or hydrocarbons are burned. When this happens they are simply exhausted directly to the atmosphere. Quench areas are places in the combustion chamber where the flame goes out before the fuel is completely burned. Small cavities such as where the head gasket seals the cylinder head to the block is a quench area. Another quench area is located between the top of the piston and the first compression ring. These areas are sources of hydrocarbon emissions.

FORMATION OF CARBON MONOXIDE

Carbon monoxide is partially burned fuel. Carbon monoxide is formed in the combustion chamber whenever there is not enough air to burn all the fuel. This means that whenever a "rich" air/fuel mixture is pulled into the combustion chamber carbon monoxide will be formed. After the flame goes out the carbon monoxide is exhausted through the tailpipe and into the air.

FORMATION OF OXIDES OF NITROGEN

Oxides of nitrogen are also formed in the combustion chamber. These oxides result from the nitrogen which is contained in our air. In some cases combustion temperatures in the automobile engine can exceed 4500°F. At temperatures above approximately 2500°F, nitrogen oxides will start forming. Therefore, if combustion chamber temperatures exceed 2500°F, oxides of nitrogen will be produced and then exhausted to our atmosphere.

Now that you understand how these emissions are formed in the automobile engine, we will see how changes in ignition timing and carburetor adjustment affect the amount of these pollutants.

As you know, changes in timing and carburetion can have a large effect on how an engine performs. These changes in timing and carburetion also can have drastic effects on the amount of pollutants which are present in the automobile's exhaust. The amount of hydrocarbons, carbon monoxide and oxides of nitrogen which are present in the exhaust gases will vary as timing and carburetion adjustments are changed.

IGNITION TIMING

Prior to emissions controlled automobiles, advancing the spark timing was a common practice. Setting the spark timing this way caused the spark plug to fire before the piston reached top dead center. This advanced spark timing allowed the maximum amount of heat energy to be

exerted on the piston. As a result the best performance and fuel economy could be obtained. Unfortunately, this also produced high hydrocarbon and nitrogen oxide emissions levels.

In order to reduce emissions levels, ignition spark timing was retarded. By firing the spark plug after the piston reaches top dead center, not as much of the heat energy is converted to work on the piston. The extra heat energy which is not used on the piston now passes through the exhaust valve and into the exhaust manifold. This keeps the exhaust gas temperatures higher. These higher exhaust tempertures allow burning of the air/fuel mixture to continue in the exhaust manifold. This further oxidation or burning in the exhaust manifold helps to reduce HC and CO emissions.

Another advantage of retarded timing from an emissions standpoint is that combustion temperatures are not as high. This is due to the fact that the maximum combustion pressure will be lower. Since the combustion temperatures will be lower and the formation of oxides of nitrogen depends on temperature, a smaller amount of these pollutants will be exhausted to the atmosphere.

There is one more advantage to using retarded spark timing. As you know, when ignition timing is retarded the engine's idle speed will drop. This decrease in idle speed occurs because less heat energy is applied to the combustion chamber and more heat energy is being supplied to continue the burning process in the exhaust manifold. In order to regain an acceptable idle speed, the throttle plates must be opened wider. This wider throttle plate opening allows more air to pass through the carburetor. This increase in air flow will reduce the amount of residual exhaust gases in the cylinder This in turn will allow a more burnable mixture which can be made leaner. Since the mixture can be leaner there will be more air in the combustion chamber. As you know, the more air that is made available during combustion the lower will be the HC and CO emissions.

CARBURETION

Adjustments made to the carburetor air/fuel ratio can also have a large effect on the amount of pollutants which come from the automobile engine. When idle mixture settings become richer there is less air present for the combustion process. This lack of air results in an increase in hydrocarbon and carbon monoxide emissions.

When idle mixture screws are turned in, the amount of fuel is reduced and the mixture becomes leaner. This leaner mixture contains more air and therefore more oxygen is available for more complete burning of the fuel. This results in lower HC and CO emissions levels.

As the idle mixture screws are turned in, the idle air/fuel mixture becomes leaner. If this mixture becomes too lean a "lean misfire" will occur. A "lean misfire" will occur because the fuel is so diluted or thinned out by the air that the mixture will not ignite. This leads to a very large increase in hydrocarbon emissions. This happens because the failure of the mixture to ignite results in that amount of raw fuel being emitted to the atmosphere.

The carbon monoxide emissions decrease when a lean misfire condition is present. Carbon monoxide is partially burned fuel. Since no combustion takes place during a lean misfire condition no CO is formed and the total amount of CO produced by the engine will be less.

A lean misfire usually occurs in one or more cylinders. This condition may also move from cylinder to cylinder while the engine is running. This is caused by the uneven distribution of the air/fuel mixture delivered to each cylinder. This condition occurs mainly because of problems with intake manifold design.

Now you should understand how changes in timing and carburetion adjustment can affect emissions levels. With this knowledge you will be able to understand how each emissions control system we will discuss helps to reduce the air pollution caused by the automobile.

SYSTEM INTRODUCTION

From what you have already learned you know that hydrocarbons and carbon monoxide are undesirable products of combustion. You also know that these two pollutants are exhausted to the atmosphere through the tailpipe of the automobile. Many of the emissions control systems are designed to help reduce these tailpipe emissions. These are the TAC system, the AIR system, EGR system, and the Spark Control system. These systems are effective in reducing the tailpipe emissions but the EPA requirements for 1975 and 1976 called for emissions levels to be lower than could be accomplished by these systems alone.

The automobile manufacturers found that a device called the catalytic converter could reduce the HC and CO emissions to a value that would meet EPA requirements for 1975 and 1976. The catalytic converter also helped to improve the driveability of the automobile. Since the catalytic converter is very effective in reducing HC and CO emissions the engine could be retuned to provide more power and performance and to provide better fuel economy.

Most 1975 and newer automobiles are equipped with catalytic converters. However, some automobiles manufactured during these years do not use catalytic converters since they meet the federal standards for HC and CO without their use.

---

1. The catalytic converter was first installed on _____ model year automobiles.

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2. Catalytic converters are installed on most 19____ and newer automobiles.

3. The device called a _____ _____ can reduce the HC and CO emissions to a value that meets EPA requirements for 1975 and 1976.

SYSTEM/COMPONENT PURPOSE

The catalytic converter system is a unique emissions control system in many ways. One aspect which makes it unique is the fact that the entire system only has one component. This is the catalytic converter itself. The purpose of the catalytic converter is to reduce the amount of hydrocarbons and carbon monoxide in the automobile exhaust. The catalytic converter provides an additional area for oxidation or burning of the HC and CO.

Another aspect of the catalytic converter system which makes it different from all the other systems is the fact that it needs a protection system. The catalyst protection system is usually built into the AIR system operation. By diverting the AIR injection air to the atmosphere instead of the exhaust manifold, it is possible to protect the catalytic converter. The purpose of the catalyst protection system is to protect the catalytic converter from damage due to overheating.

---

4. One aspect which makes the catalytic converter system unique is that the entire system has only _____ component.

---

5. Catalytic converter systems reduce the amount of hydrocarbons (HC) and carbon monoxide (CO) in the automobile exhaust by providing an additional area for _____ to occur.

---

6. The catalyst protection system's purpose is to protect the catalytic converter from damage caused by _____.

SYSTEM/COMPONENT FUNCTION

As you recall from the previous section of the book, the catalytic converter provides an additional area to oxidize or burn the HC and CO after it leaves the engine. This in turn will reduce the total amount of hydrocarbons and carbon monoxide in the exhaust gases. Since you are now familiar with the purpose of the catalytic converter system, let's take a closer look at how it accomplishes its job.

The catalytic converter is a component which looks much like another

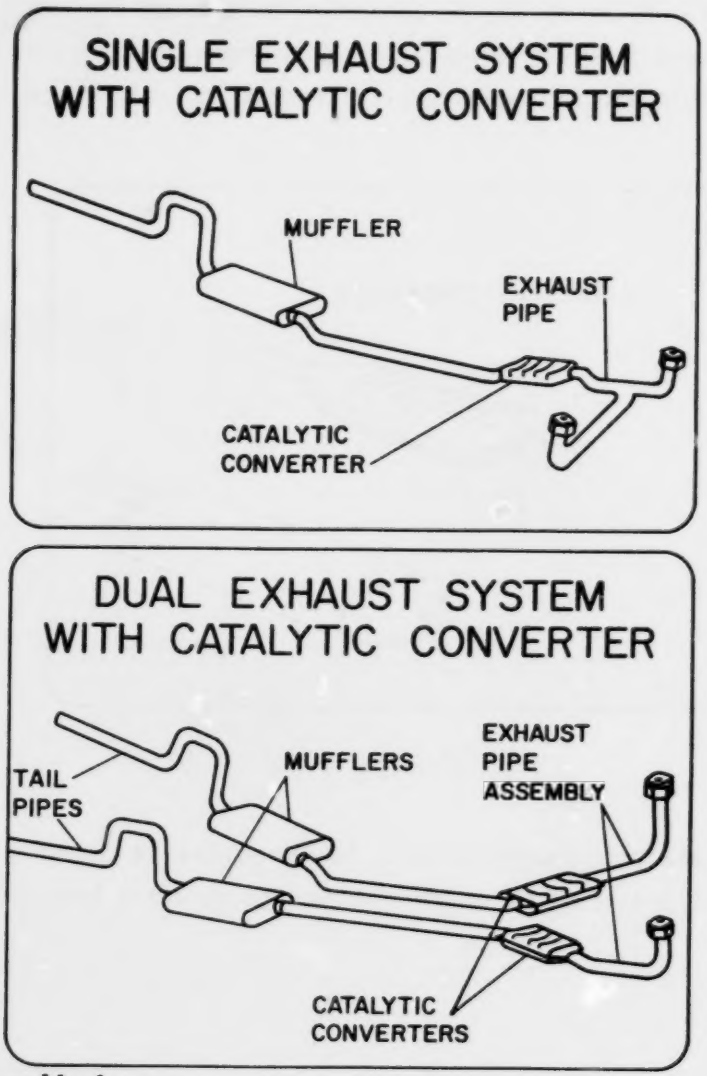

FIGURE 7-1.

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muffler. It is usually located in the exhaust system ahead of the muffler and fairly close to the exhaust manifold. There is one catalytic converter used on cars equipped with single exhaust systems. Cars which are equipped with a dual exhaust system however, will usually have two catalytic converters. They will be located close to both exhaust manifolds. Figure 7-1 shows the location of the catalytic converters used for both systems.

As you can see in figure 7-2, there is one difference which distinguishes the catalytic converter from an ordinary muffler. This difference is the material from which the catalytic converter is constructed. The outer skin or shell of the catalytic converter is made of stainless steel. Stainless steel is used for catalytic converter construction because it is more durable and corrosion-resistant than the metal used in ordinary mufflers.

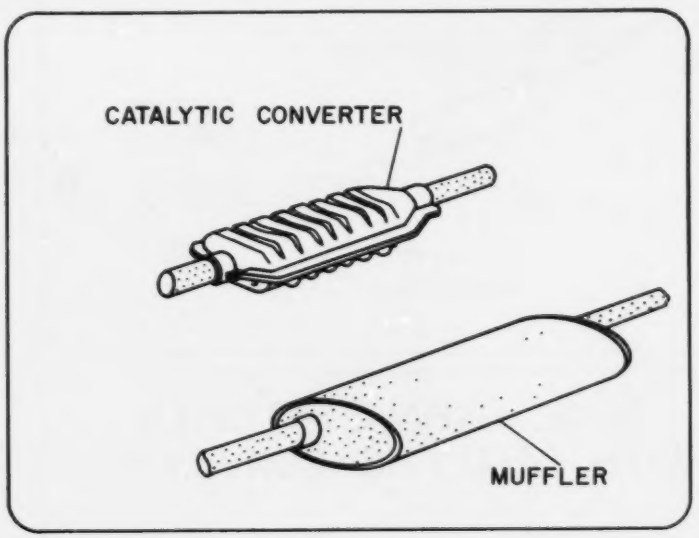

FIGURE 7-2

Since the catalytic converter is a fairly expensive component, it is desirable to construct it in this manner to assure a long component life span.

There are two basic internal designs used for catalytic converters. These are the monolith design and the pellet design. Both types have their advantages and disadvantages as well as differences in construction. We will first look at the monolith type catalytic converter.

7. A catalytic converter looks like a _____.

8. The two internal designs of catalytic converters are the _____ design and the _____ design.

MONOLITH TYPE CONVERTER

Figure 7-3 shows a cut-away view of the monolith type catalytic converter. Contained inside the stainless steel shell is a flow diffuser, a honeycomb monolith, and a stainless steel mesh. As the arrow in figure 7-3 indicates the exhaust gases enter the monolith type catalytic converter and first

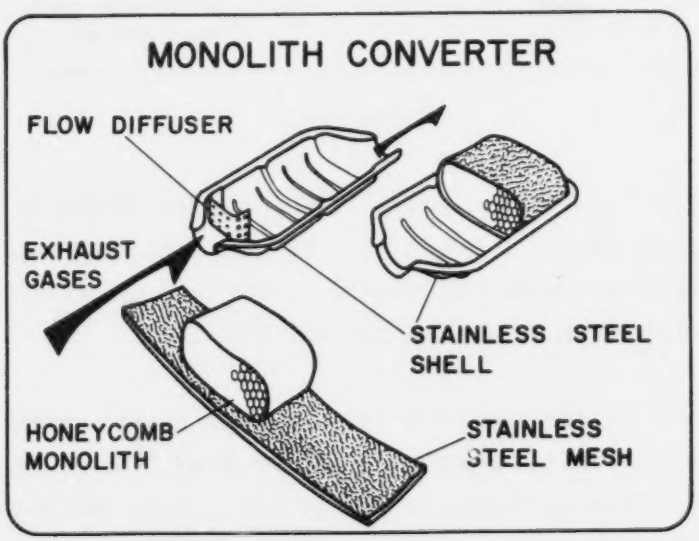

FIGURE 7-3

encounter the flow diffuser. This flow diffuser is designed to spread or diffuse the exhaust gases for a more even flow through the monolith element.

The monolith element is a honeycomb type design. This monolith has hundreds of small passages which the exhaust gases flow through. A ceramic material is used to make this monolith element. As figure 7-4 shows, this ceramic material is coated with a very thin layer of platinum and palladium. This coating of platinum and palladium is the key to the catalytic converter as we shall see later.

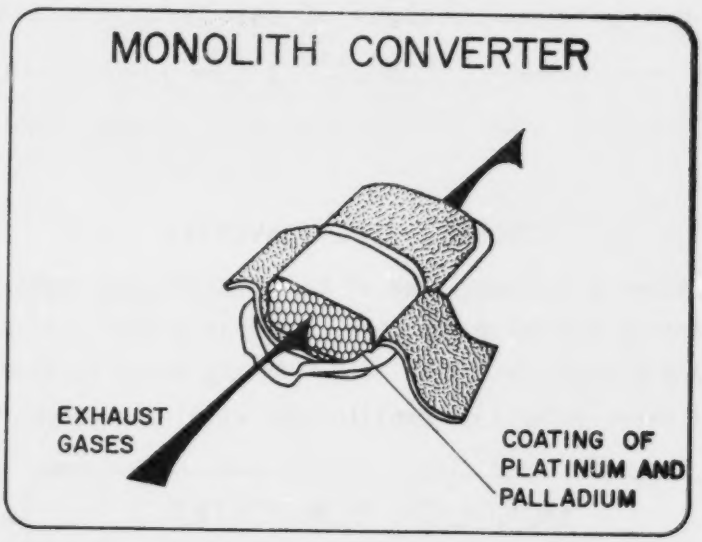

FIGURE 7-4

Surrounding the monolith element, as you can see in figure 7-3, is a stainless steel mesh. This mesh has been put into the catalytic converter shell to cradle the monolith element. This mesh protects the fragile ceramic element from damage due to road shock.

Now you should be familiar with this monolith design catalytic converter. We will now look inside a pellet type converter. As you will see, this converter is quite different in design but it does the very same job.

PELLET TYPE CONVERTER

Figure 7-5 shows a cut-away view of the pellet type catalytic converter. This type of catalytic converter contains baffles, baffle plates, insulation and aluminum oxide pellets inside its stainless steel shell. As

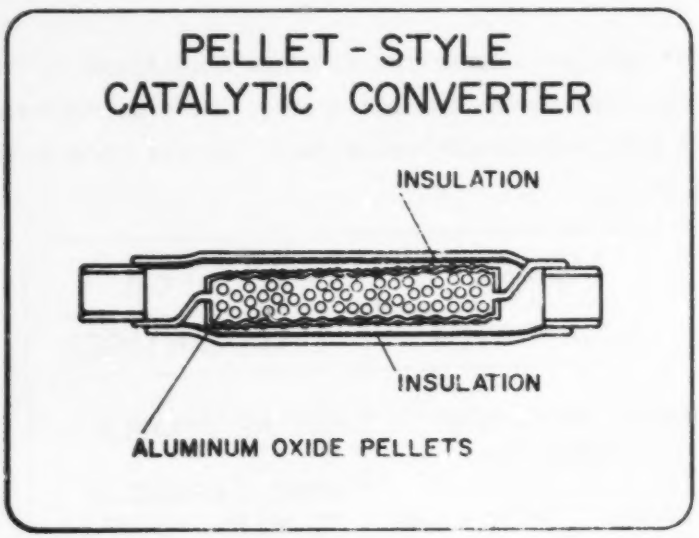

FIGURE 7-5

the exhaust gases enter this type of catalytic converter, they first encounter a baffle which directs the gases upward. The only way for the

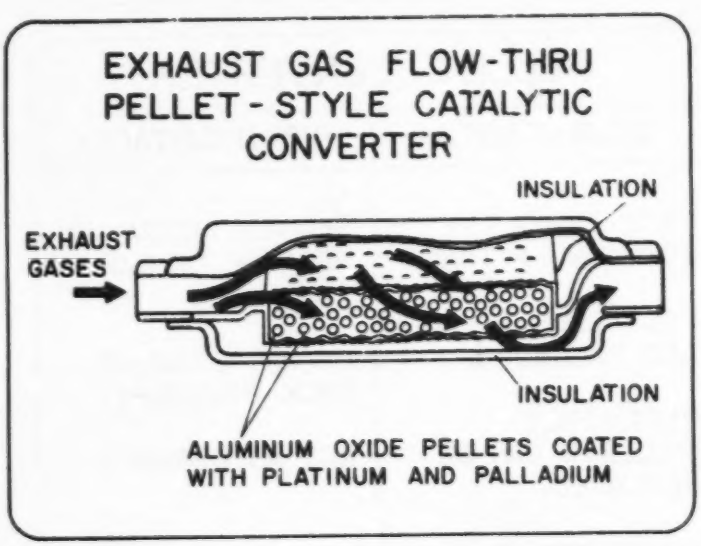

FIGURE 7-6

gases to flow through the converter is to pass through the holes in the baffle plate. These gases then pass down through the bed of aluminum oxide pellets and are directed out of the converter by another baffle. The arrows in figure 7-6 show the path which the exhaust gases take when flowing through the pellet type catalytic converter.

This type of catalytic converter also has insulation in its shell to keep the heat contained inside the converter. The aluminum oxide pellets are coated with platinum and palladium just like the ceramic core of the monolith type.

MONOLITH CONVERTER	
ADVANTAGES	**DISADVANTAGES**
MORE RESISTANT TO VIBRATION	NOT REPAIRABLE
SMALL, THEREFORE FAST HEAT-UP	MORE EXPENSIVE TO MANUFACTURE
LESS EXHAUST BACK PRESSURE	REQUIRES MORE PLATINUM AND PALLADIUM

PELLET CONVERTER	
ADVANTAGES	**DISADVANTAGES**
LESS EXPENSIVE TO MANUFACTURE	SLOWER WARM-UP BECAUSE OF LARGER SIZE
USES LESS PLATINUM AND PALLADIUM	HIGHER EXHAUST BACK PRESSURE
REPAIRABLE (PELLETS CAN BE REPLACED)	NOT AS DURABLE

FIGURE 7-7

Both styles of catalytic converters operate in the same way. However, each has their own advantages and disadvantages. Figure 7-7 contains charts which list these for each type of catalytic converter.

9. When the exhaust gases enter the monolith type catalytic converter, they first encounter a _____ _____.

10. The monolith element is a _____ type design.

11. The monolith element is made of a _____ material.

12. The pellet type converter uses small _____ _____ pellets approximately 1/8" to 3/16" in diameter.

13. The small pellets are coated with a very thin layer of _____ and _____.

CATALYSTS

Platinum and palladium are the key to the catalytic converter. These two elements are used in both types of catalytic converters. These elements act as the catalytic agents or the catalysts. A catalyst is a substance that is used to speed up a chemical reaction or chemical change. Both types of converters use about 70 percent platinum and 30 percent palladium.

Platinum is a more efficient catalyst but it is also very expensive. Palladium is less efficient as a catalyst but is less expensive. By using both catalysts it is possible to have a catalytic converter which has the needed efficiency and a reasonable cost.

The catalyst is a substance used to speed up a chemical reaction or chemical change. As you can see in figure 7-8, in automobile applications the catalyst speeds up the change of HC and CO. These harmful

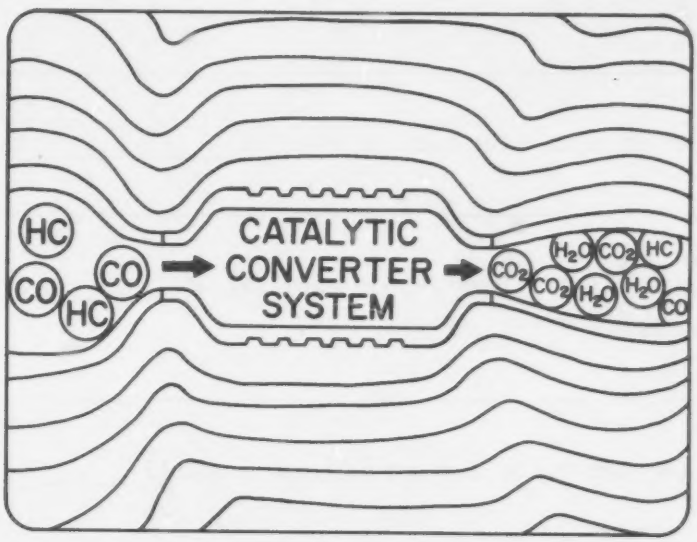

FIGURE 7-8

gases are converted to H_2O and CO_2. These are harmless substances, water vapor and carbon dioxide. The catalytic converter does this by adding oxygen, or oxidizing the HC and CO.

In order for the catalytic converter to oxidize the HC and CO, a burning must take place. This burning takes place in the catalytic converter itself. When this secondary burning takes place in the catalytic converter, heat will be given off. The temperature of this burn will usually be about 200°F hotter than the exhaust temperature. The catalytic converter needs heat to function correctly. In fact, the converter won't start to operate until the exhaust temperatures reach

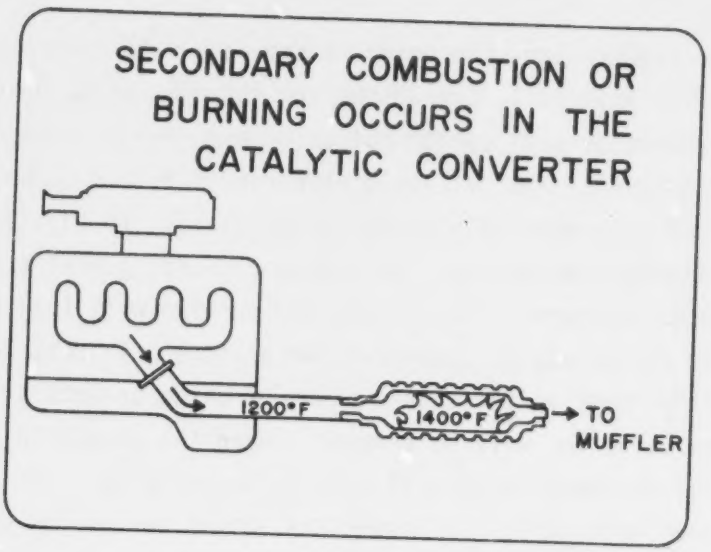

FIGURE 7-9

500°F. When the automobile is operating normally the temperature inside the catalytic converter will be approximately 1400°F. When the inside of the converter is at this temperature the outer shell will heat to about 700°F.

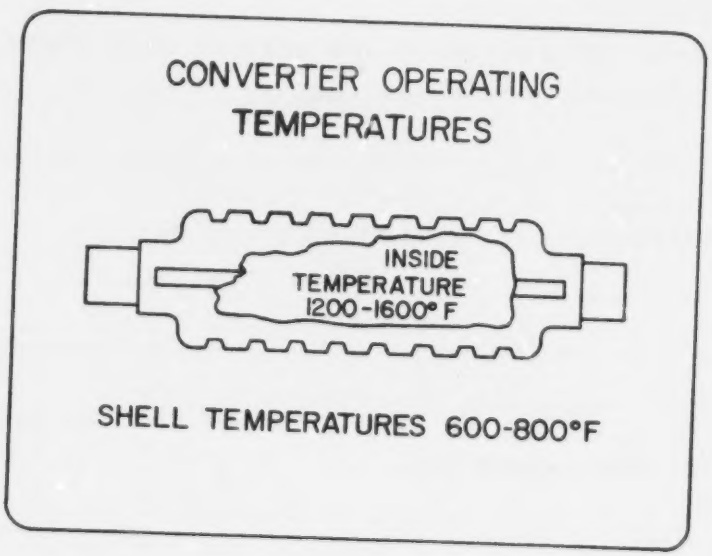

FIGURE 7-10

Much higher temperatures can occur in the catalytic converter. Whenever an overly rich mixture is present during the combustion process, the catalytic converter will become hotter. This rich mixture can be caused by a spark plug misfire. It could also result from a carburetor malfunction such as a partially closed choke plate. If this overly rich condition occurs, an increased oxidation or burning will take place in the catalytic converter. This increased burning will lead to a rapid increase in the catalytic converter temperature. If this temperature reaches approximately 2500°F, the aluminum oxide pellets or the ceramic core of the converter will be damaged. When the catalytic converter is damaged from overheating it will have to be replaced. For this reason, cars equipped with catalytic converters should not be run with spark plug wires that are open, disconnected or shorted. If the shorting or disconnecting of a spark plug is required for any reason, the engine should not be operated for over 30 seconds. Any condition which allows an overly rich mixture to reach the catalytic converter should be corrected immediately to prevent catalytic converter damage.

---

14. Platinum and palladium are used in both converters, as the catalytic agents or the _____.

---

15. A substance that is used to speed up a _____ _____ is called a catalyst.

---

16. _____ is the better of the two catalysts, but it is very expensive.

---

17. The purpose of the oxidizing catalytic converter is to oxidize or add _____ to certain harmful elements and compounds in the exhaust gas.

18. In automotive applications, the chemical compounds that require oxidizing are _____ and _____ _____.

19. In order to prevent possible damage, any condition which allows an excessively rich air/fuel mixture to reach the _____ _____ should be corrected immediately.

CATALYST PROTECTION SYSTEMS

Since the catalytic converter can be severely damaged if overheated, many manufacturers have installed a catalyst protection system on their automobiles. The purpose of the catalyst protection system is to protect the catalytic converter from damage due to overheating. We will now look more closely at some catalyst protection systems and learn how they function.

Figure 7-11 shows a catalyst protection system which is used by the Chrysler Corporation on many of their automobiles. This system is designed to protect the catalytic converter during periods of deceleration. Normally when the automobile decelerates, the air/fuel mixture becomes excessively rich. This system prevents this condition from occurring. When the engine speed exceeds 2000 RPM the throttle position

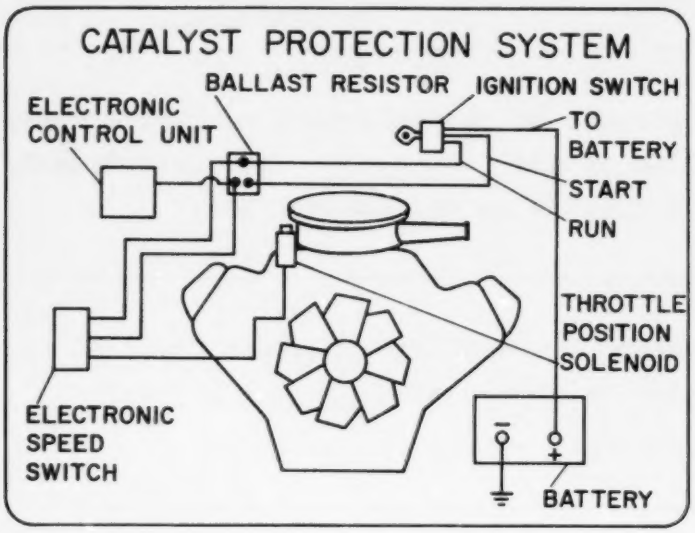

FIGURE 7-11

solenoid is energized by a signal from the electronic speed switch. When the throttle is then released, this throttle position solenoid will hold the throttle at a preset point corresponding to 1500 RPM. The electronic speed switch senses when engine speed drops below 2000 RPM and it then de-energizes the throttle position solenoid. This allows the throttle plates to fully close to the curb idle position. By keeping the throttle plates at a 1500 RPM position, this catalyst protection system allows enough air to enter the engine during deceleration. This extra air prevents an excessively rich mixture and protects the catalytic converter from overheating.

Ford uses a catalyst protection system that is built into the operation of the AIR system. The AIR system provides the necessary air for the proper operation of the catalytic converter. Figure 7-12 shows this catalyst protection system.

This system protects the catalytic converter by diverting injection air to the atmosphere during four specific engine conditions. There are rich engine warm up, engine deceleration, overheated engine operation and

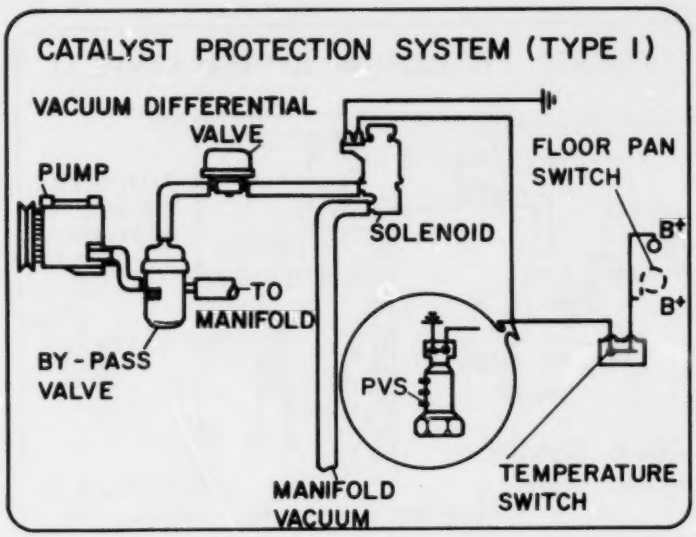

FIGURE 7-12

periods of excessive floor pan temperatures caused by the catalytic converter.

As you can see in figure 7-12, the main components of this system are the by-pass or diverter valve, the vacuum differential valve (VDV), the vacuum solenoid, the ported vacuum switch (PVS), the air cleaner temperature switch and the floor pan switch.

The by-pass valve used in this system works in a different way than a normal AIR by-pass valve. This valve will inject air into the exhaust manifold any time a vacuum signal is present. Whenever this vacuum drops to 0 the by-pass valve will divert the air to the atmosphere.

The vacuum solenoid is connected into the system in such a way that it must be energized to allow the vacuum signal to reach the by-pass valve. The switches in this system are closed during normal engine operation. If any of these switches open the solenoid will de-energize. This will prevent the vacuum from reaching the by-pass valve and the injection air will be dumped to the atmosphere. Figure 7-13 shows the catalyst

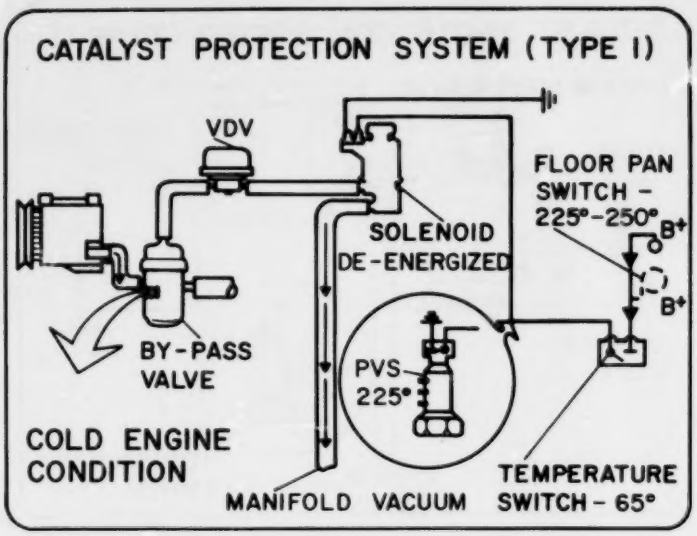

FIGURE 7-13

protection system in this "open switch" position. You can see that the temperature switch is below 65°F.

The vacuum differential valve is used to dump injection air for the first few seconds of deceleration. Under normal cruising operation, a vacuum

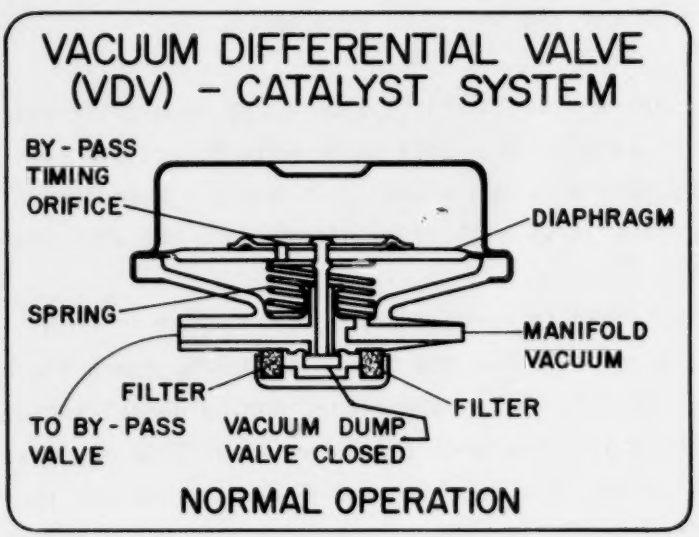

FIGURE 7-14

will be present on both sides of the diaphragm. This is made possible by the small timing orifice connecting both sides of the diaphragm. This condition may be seen in figure 7-14.

In this position the vacuum differential valve will allow the vacuum signal to reach the by-pass valve. This in turn will permit the by-pass valve to inject air into the exhaust manifold. During the first few seconds of deceleration the higher intake manifold vacuum will act on the lower side of the diaphragm. This will pull the diaphragm down against the spring pressure. When this happens the vacuum dump valve will open allowing air to bleed into the vacuum line. This will cause the by-pass valve to divert injection air to the atmosphere. This may be seen in figure 7-15. When the vacuum on both sides of the diaphragm becomes equal the vacuum dump valve will close and the by-pass valve will again direct injection air to the exhaust manifold.

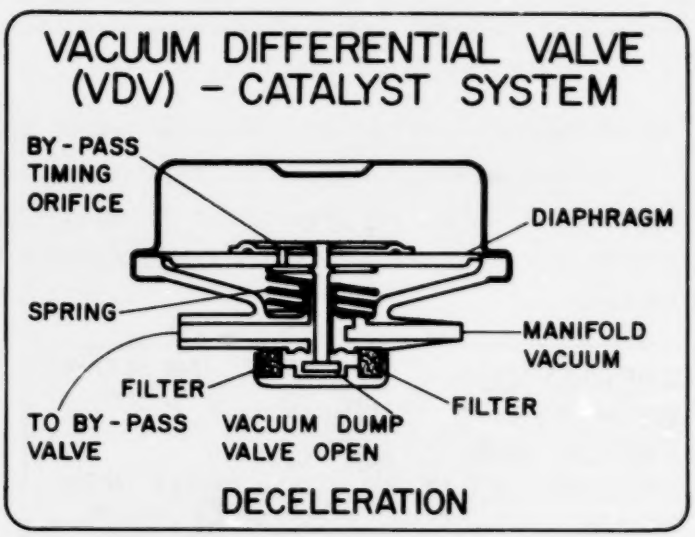

FIGURE 7-15

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20. Ford modified the _____ system operation to protect the catalytic converter.

---

21. Ford's catalyst protection system includes the diverter valve, the vacuum _____ valve, the vacuum solenoid, the ported vacuum switch, the air cleaner temperature switch and the floor pan switch.

22. A _____ vacuum source is used for the operation of Ford's by-pass valve.

23. With no vacuum signal, the _____ valve will dump air to atmosphere.

Ford used another type of catalyst protection system on some of their later cars. This system was designed to prevent EGR system operation during cold engine operation, and prevent air injection during extended periods of engine idle. Figure 7-16 shows the components of this catalyst protection system.

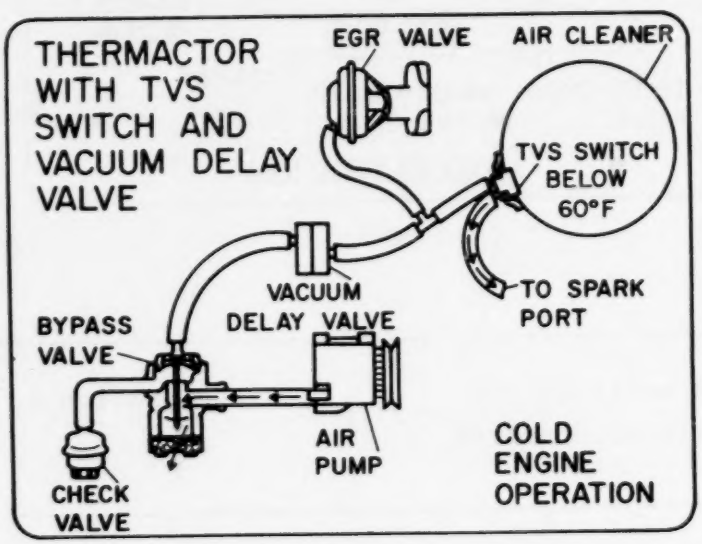

FIGURE 7-16

Figure 7-16 shows this system with the thermal vacuum switch (TVS) closed. This will occur anytime the intake air is below 60°F. In this position the TVS switch will block the ported vacuum signal. In this state of operation the EGR system will not operate and the AIR system will dump its air to the atmosphere.

When the intake air temperature rises above approximately 60°F, the TVS switch opens. As the throttle is opened, a ported vacuum signal is available to operate the EGR system. This same ported vacuum signal passes through the vacuum delay valve to the by-pass valve. This vacuum at the by-pass valve causes injection air to be directed to the exhaust manifold. This operation is shown in figure 7-17.

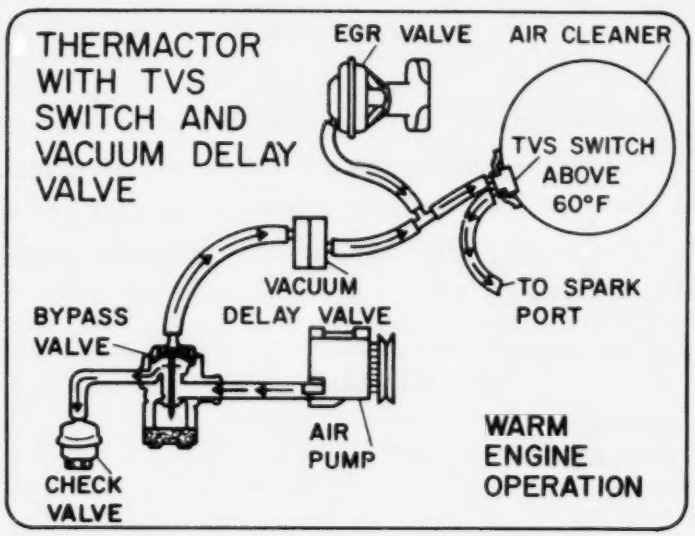

FIGURE 7-17

During periods of extended idle, the throttle plates are nearly closed, and there is no ported vacuum signal. The vacuum which is trapped between the by-pass valve and the vacuum delay valve will slowly bleed through the delay valve. When this vacuum bleeds off and approaches 0" the by-pass valve will divert injection air to the atmosphere. This vacuum will bleed off in approximately 30 to 60 seconds. Figure 7-18 shows the

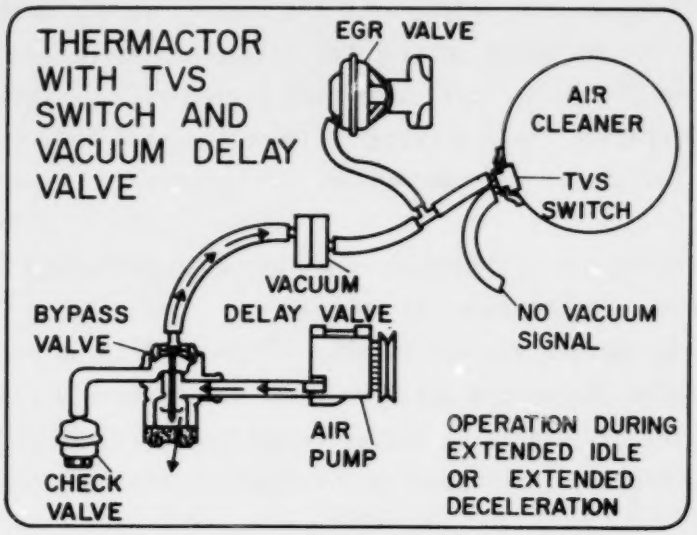

FIGURE 7-18

catalyst protection system in this operating condition. By removing this injection air from the exhaust system the amount of oxidation or burning which takes place in the catalytic converter will be reduced. This prevents the excessively high temperature that would otherwise occur in the catalytic converter.

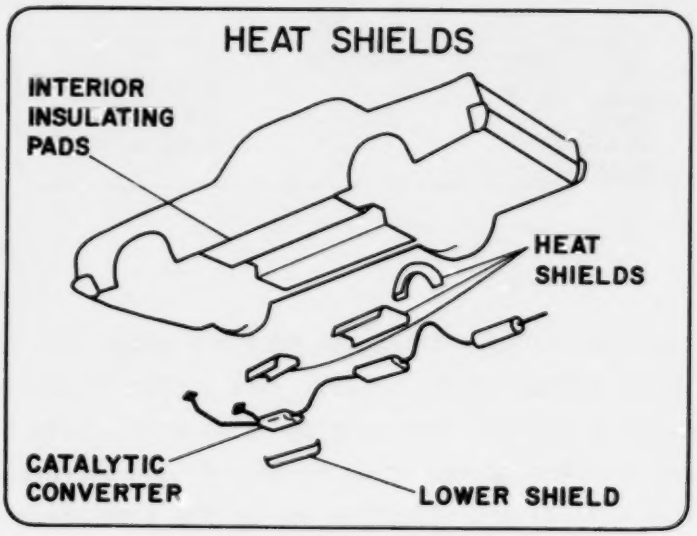

FIGURE 7-19

Since the catalytic converter may reach very high skin temperatures, some manufacturers have protected the under carriage of their automobiles. Figure 7-19 shows the heat shields used to protect the under carriage components from the catalytic converters additional heat. In addition, vehicles designed for heavy duty operation, such as trailer towing, will have special insulation beneath the carpeting. This will decrease the heat buildup inside the vehicle.

You should now have a basic understanding of the protection systems required for the catalytic converter. However, you must be aware that the catalyst protection systems will vary greatly between individual automobile manufacturers and models. For this reason, you should always consult the manufacturer's service manual.

All automobiles using a catalytic converter must use lead-free or unleaded fuel. This is because the lead in leaded fuel will coat the platinum and palladium catalyst material. This coating of lead will destroy the effectiveness of the catalytic converter and the catalyst will need to be replaced.

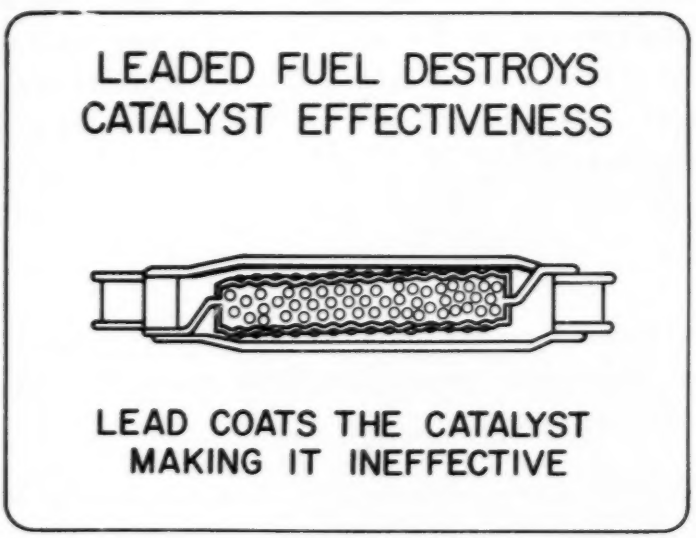

FIGURE 7-20

Since leaded gasoline will destroy a catalytic converter a special fuel tank filler neck has been installed on all catalytic converter equipped automobiles. This is shown in figure 7-21. A special small diameter

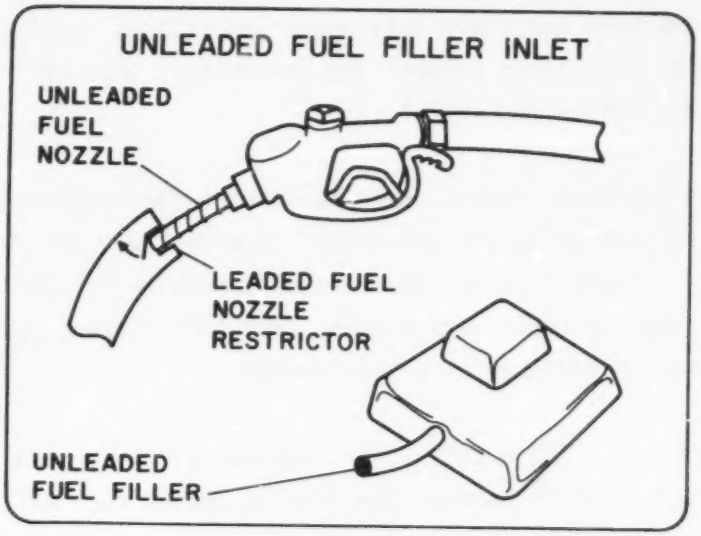

FIGURE 7-21

unleaded fuel nozzle must be used to fill the tank. The unleaded fuel nozzle is the only nozzle that will fit in the new small diameter filler neck. In addition, a spring loaded door inside the filler neck is used. This prevents fuel from being added by any other means except the small diameter fuel nozzle.

---

24. Some manufacturers have added _____ sheilds to protect under carriage components from the catalytic converter's additional heat.

---

25. _____ fuel must be used with any vehicle equipped with a catalytic converter.

Now you should be familiar with the function of the catalytic converter system. We can now take a brief look at the inspection and testing procedures for this system.

SYSTEM INSPECTION

An inspection of the catalytic converter system should be made periodically and previous to any testing of the system. This inspection will require no tools or instruments and will take only a few minutes. Many problems may be avoided or corrected by these steps.

1. Check to see that all components are properly installed on the engine and no modifications have been done. The catalytic converter or converters should be in place. In addition, all catalyst protection system components and connecting hoses should be in place.

   In order for the catalytic converter system to function as it was designed, the catalytic converter must be installed correctly. In addition, the catalyst protection system must be installed correctly in order to protect the catalytic converter from damage due to overheating.

2. Check the catalyst protection system connecting hoses for cracks, deterioration and loose connections.

   Any air leaks into the catalyst protection system hoses can reduce the effectiveness of the system. If air leaks are excessive the catalyst protection system may fail to operate at all. An excessive air leak can also cause a lean misfire in the engine cylinders.

3. Check the catalytic converter itself for evidence of physical damage.

   Look for large dents, ruptures, or punctures. Also check for evidence of converter overheating. This can be seen by high temperature discoloration or signs of scorching on the vehicle underbody.

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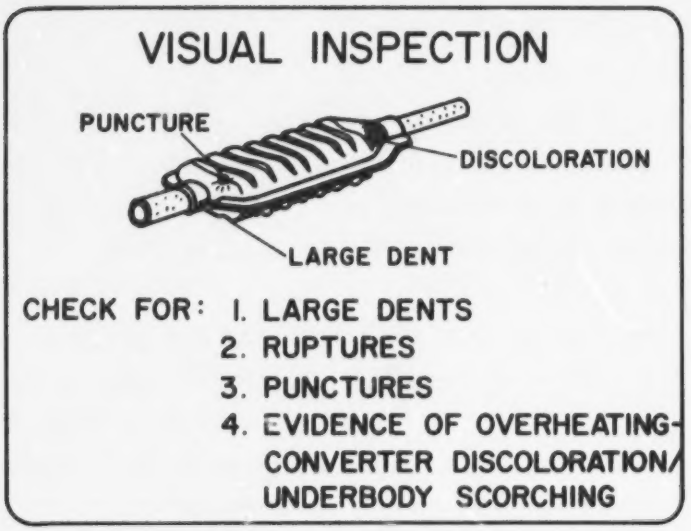

FIGURE 7-22

If the catalytic converter has been excessively damaged it will fail to operate as it was designed and will have to be replaced.

---

26. When inspecting the catalytic converter, check for evidence of physical damage such as dents or punctures. Also, check for evidence of converter _____

---

27. Any _____ _____ into the catalyst protection system hoses can reduce the effectiveness of the system.

---

28. An excessive air leak in the catalyst protection system can cause a lean _____ in the engine cylinders.

SYSTEM TESTING

For specific information on testing and setting catalyst protection system components, it is recommended that the manufacturer's shop or service manual or a good emissions control manual be used. This is required because of protection system variations between different models and manufacturers.

SYSTEM SUMMARY

PURPOSE

Catalytic converter systems reduce the amount of hydrocarbons (HC) and carbon monoxide (CO) gas in automobile emissions by providing an additional area for exhaust gases to oxidize or burn. This is accomplished by using a chemical catalyst to speed up the oxidizing process.

MAIN COMPONENTS

Outer Shell - Shaped much like a muffler, the outer shell of the catalytic converter is made of stainless steel to increase durability and rust resistance.

Monolith Element - Used on monolith design converters, the monolith element is a honeycomb of small ceramic passageways. A very thin layer of platinum and palladium is used to cover the ceramic element. The entire element is surrounded by a stainless steel mesh for protection.

Aluminum Oxide Pellets - Used on pellet designed converters, a bed of Aluminum Oxide pellets 1/8"-3/16" diameter are coated with a thin layer of platinum and palladium. The exhaust gas is directed to flow through these pellets.

Platinum and Palladium - Common elements in both the monolith and pellet design converters are the two noble metals, platinum and palladium, used as catalytic agents. (A catalyst is a substance that is used to speed up a chemical reaction.) Both types of converters are approximately 70% platinum and 30% palladium in the thin film covering their interior elements.

SYSTEM FUNCTION

As exhausted gas leaves the manifold it enters the catalytic converter. There the gas is directed to flow over the interior monolith or pellets covered by the catalytic agents, platinum and palladium. When this happens, the exhaust gases increase their temperatures and continue to

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oxidize, removing hydrocarbon (HC) and carbon monoxide (CO) emissions from the exhaust before it enters the muffler. As the heat developed in the catalytic converters is very high, auto manufacturers are devising various methods of control and insulation to insure its safe operation.

ANSWERS

1. 1975
2. 1975
3. catalytic converter
4. one
5. oxidation or burning
6. overheating
7. muffler
8. monolith, pellet
9. flow diffuser
10. honeycomb
11. ceramic
12. aluminum oxide
13. platinum, palladium
14. catalyst
15. chemical reaction or chemical change
16. platinum
17. oxygen
18. hydrocarbons, carbon monoxide
19. catalytic converter
20. AIR
21. differential
22. manifold
23. bypass
24. heat
25. lead free or unleaded
26. overheating
27. air leaks
28. misfire

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